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FIG. 1

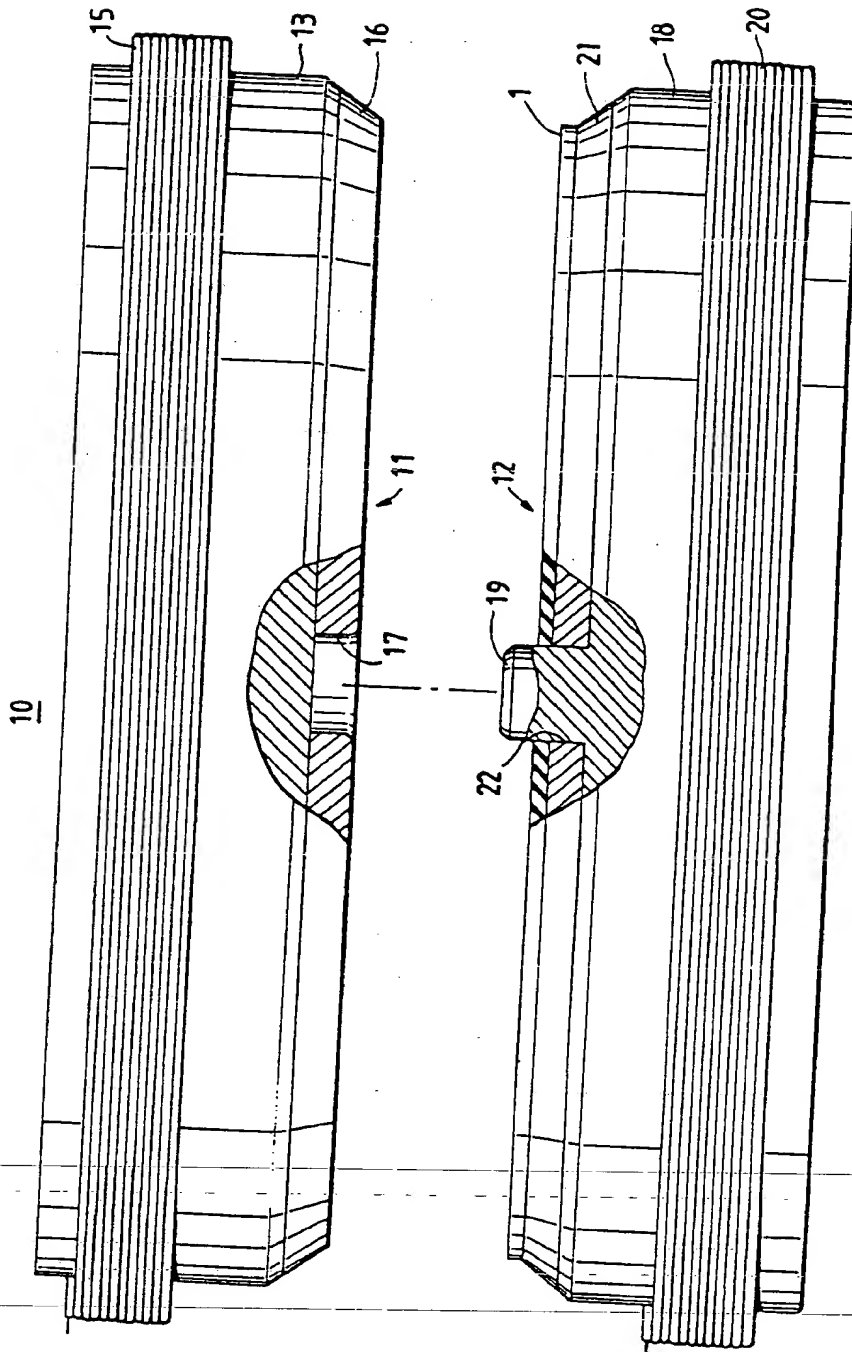


FIG. 2A

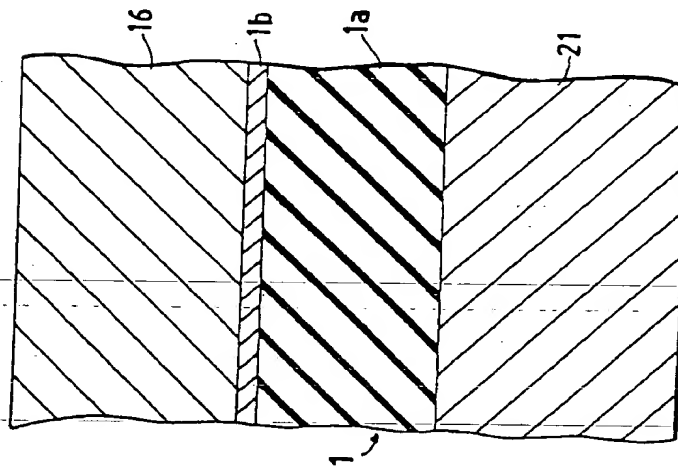


FIG. 2B

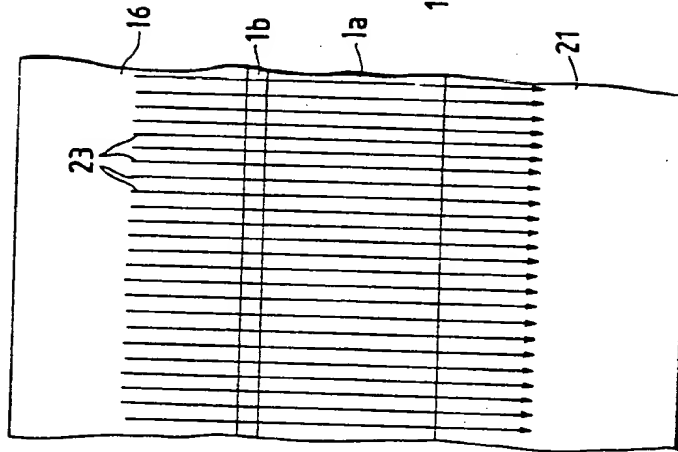
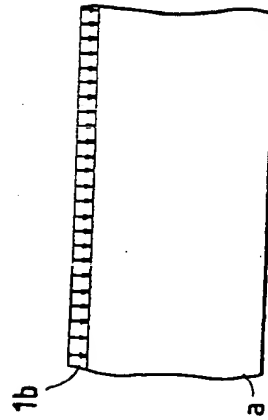


FIG. 2C



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2164483

FIG. 3

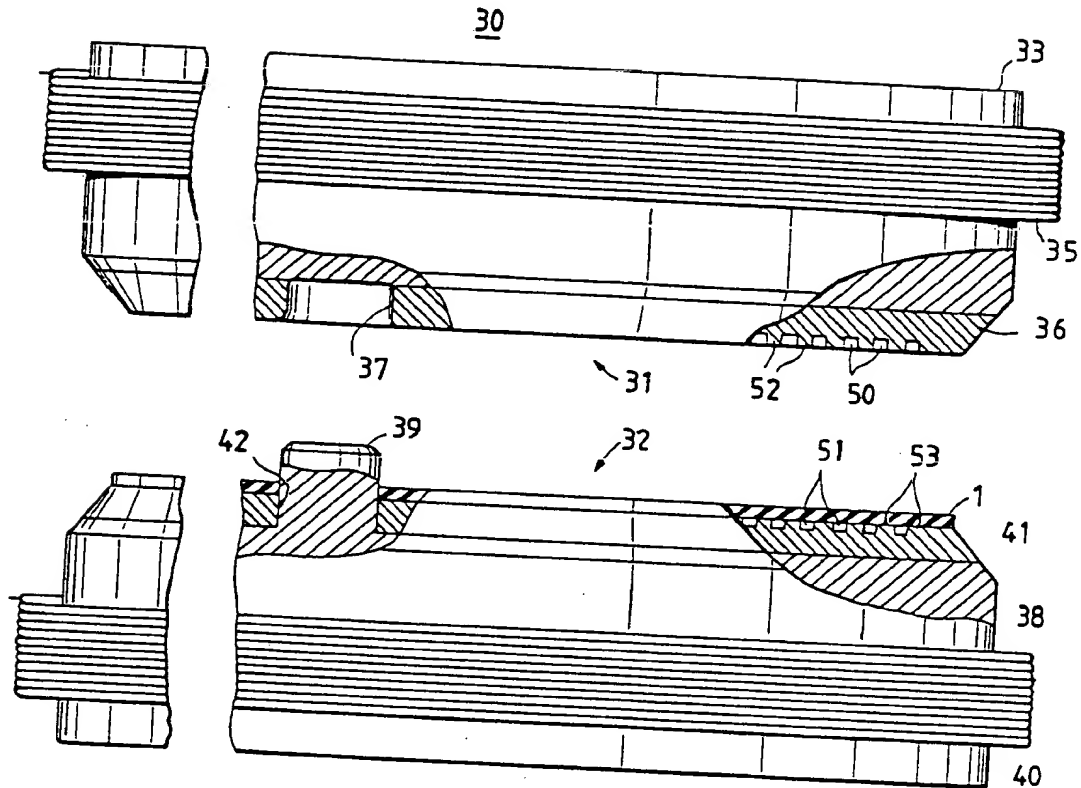


FIG. 4

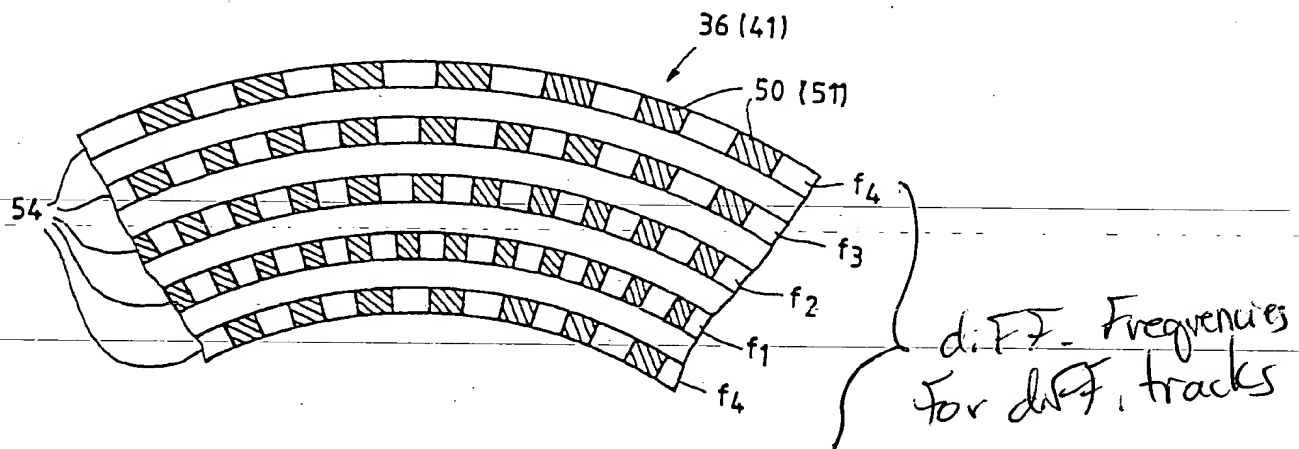


FIG. 5C

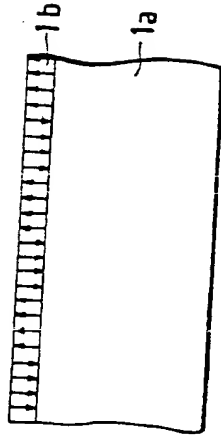


FIG. 6

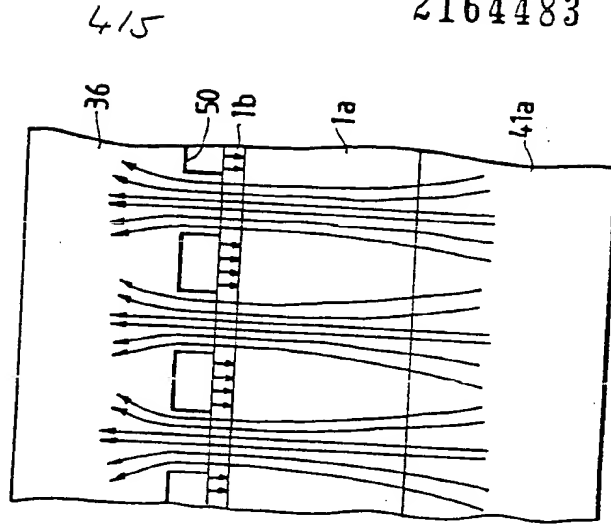


FIG. 5B

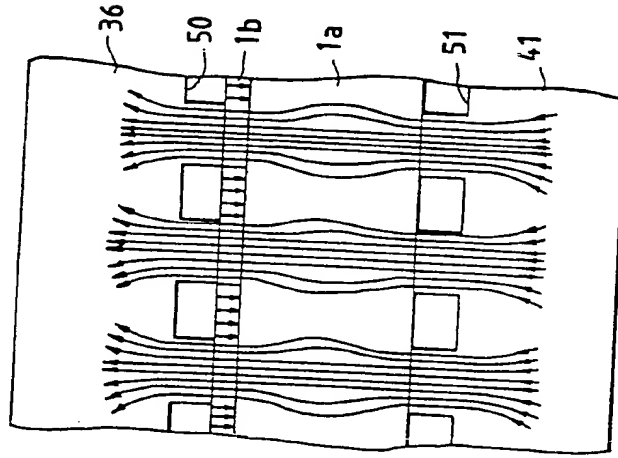


FIG. 5A

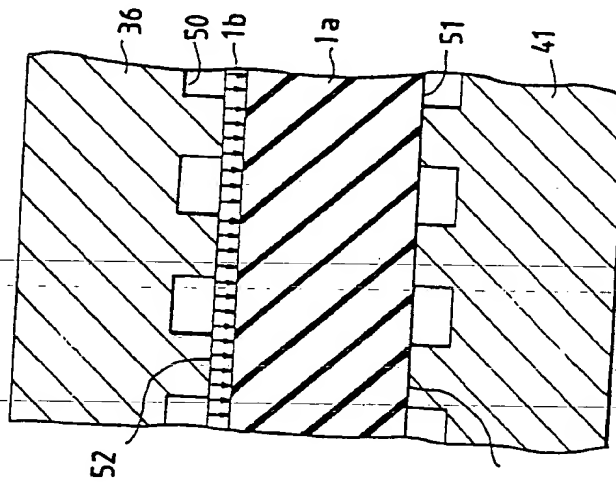


FIG. 7A

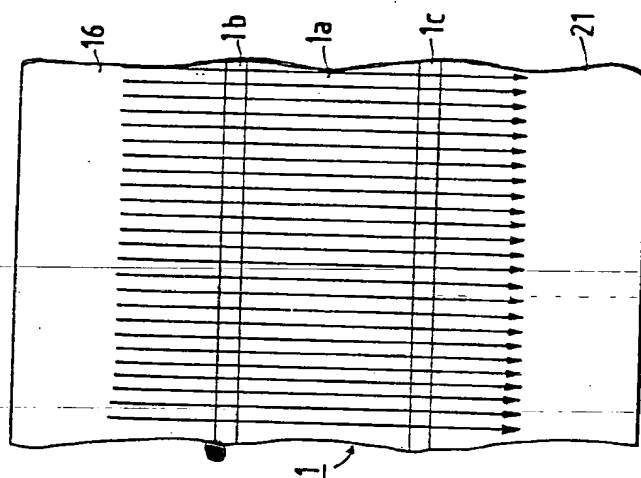


FIG. 7B

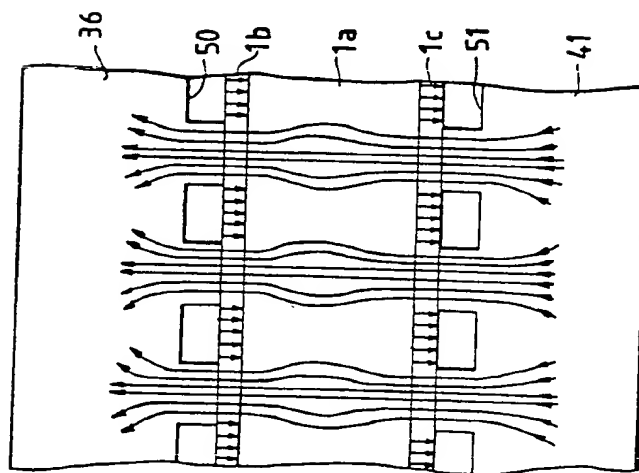
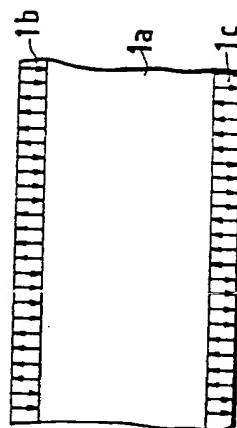


FIG. 7C



SPECIFICATION

Method for recording servo control signals on a magnetic disc

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The present invention relates to a method and apparatus for recording servo control signals on magnetic record mediums for use in buried servo-controlled magnetic recording and playback systems.

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In conventional magnetic recording systems operating on a buried servo control principle, a magnetic head is used to record servo control signals for track following purposes during write and readout operations. This is accomplished by scanning a recording head along concentric or spiral tracks and recording a servo control signal having a frequency much lower than the frequencies of information signals. The magnetic head used for this purpose has a greater gap length than those used for writing and reading information signals. Because of the difference in gap width, magnetic flux lines produced by the servo control signals extend down to the bottom of the record medium while those produced by the information signals do not, allowing the latter to be recorded on an upper layer of the medium and leaving the servo control signals buried in the lower layer of the medium.

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One disadvantage of the conventional method is that the recording hardware construction must be of high precision and stability sufficient to enable the recording magnetic head to move in a radial direction with a close tolerance over the surface of a spinning magnetic disc. Another disadvantage is that it takes a substantial amount of time to record the servo control signals.

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It is therefore an object of the present invention to provide a novel method and apparatus for recording servo control signals on a magnetic record medium such as floppy disc.

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The method of the invention comprises the steps of subjecting a magnetic record medium to a first magnetic field for uniformly magnetizing the medium in a direction of the thickness thereof, contacting the uniformly magnetized record medium in a face-to-face relationship with a surface of a ferromagnetic member on which a plurality of spaced geometrically varying regions are arranged in track turns, and subjecting the record medium and the ferromagnetic member to a second magnetic field oriented in a direction opposite to the direction of orientation of the first magnetic field to produce in the record medium a plurality of spaced regions magnetized in a direction opposite to the direction of magnetization by the first magnetic field.

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According to another aspect, the present invention provides an apparatus for recording servo control signals on a record medium. The apparatus comprises first magnetizing means

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for generating a first magnetic field in a direc-

tion of the thickness of the record medium and subjecting the record medium in the first magnetic field to uniformly magnetize the medium. Further included is a second magnetizing means comprising a ferromagnetic member having a plurality of spaced geometrically varying regions arranged in track turns on one surface thereof for generating a second magnetic field oriented in a direction opposite to the direction of orientation of the first magnetic field and subjecting the uniformly magnetized record medium and the ferromagnetic member in a face-to-face relationship with each other in the second magnetic field to produce in the record medium a plurality of spaced regions magnetized in a direction opposite to the direction of magnetization by the first magnetic field.

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The present invention will be described in further detail with reference to the accompanying drawings, in which:

Fig. 1 is a side elevational view of an apparatus of the invention used for uniformly magnetizing a single-sided magnetic floppy disc;

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Fig. 2A is an enlarged cross-sectional view of a portion of the magnetic disc interposed between ferromagnetic members within the apparatus of Fig. 1, and

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Figs. 2B and 2C are views illustrating magnetic fields generated in the magnetic disc of Fig. 1;

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Fig. 3 is a side elevational view of an apparatus of the invention used for locally magnetizing the uniformly magnetized disc in a direction opposite to the direction of magnetization of the apparatus of Fig. 1;

Fig. 4 is an illustration of a pattern of servo control signals recorded on a surface of each ferromagnetic disc of Fig. 2;

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Fig. 5A is an enlarged cross-sectional view of a portion of the floppy disc interposed between ferromagnetic discs bearing the pattern of Fig. 4, and Figs. 5B and 5C are views illustrating magnetic fields generated in the disc of Fig. 3;

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Fig. 6 is an illustration of a modified embodiment; and

Figs. 7A, 7B and 7C are illustrations showing a magnetic field distributions within a double-sided floppy disc.

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Shown in Fig. 1 is an apparatus 10 used in a first-stage of the method of recording servo control signals on a magnetic disc record medium such as floppy discs according to the present invention. Apparatus 10 comprises an upper electromagnet 11 which is fixed to a suitable elevating mechanism, not shown, and a lower electromagnet 12 which is mounted on a base, not shown. Upper electromagnet 11 comprises a cylindrical core 13 and a coil 15 wound on the core. To the underside of the core 13 is fixed a ferromagnetic disc 16 having a center alignment hole 17.

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Lower electromagnet 12 comprises a cylindrical core 18 having a spindle 19 and a coil

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20 wound on the core 18. A ferromagnetic disc 21 having a center hole 22 mounted on the core 18 with the hole 22 engaging with the spindle 19.

5 A floppy disc 1 is placed on the ferromagnetic disc 21. Upper magnet 11 is then lowered so that the spindle 19 is received in the hole 17 and the floppy disc 1 is sandwiched between the upper and lower ferromagnetic
10 discs 16 and 21 as illustrated in Fig. 2A. In one example, the floppy disc 1 is of a conventional single-sided type having a single layer 1b of magnetic material on a base 1a. Upper and lower coils 15 and 20 are then
15 energized by DC currents to generate a uniform magnetic field as indicated by downwardly-pointed arrows 23 shown in Fig. 2B. In this way, the magnetic layer 1b remains uniformly magnetized in a vertical direction (Fig.
20 2C) and withdrawn from the apparatus 10.

An apparatus 30 shown in Fig. 3 is used in the second stage of the method of the invention. Apparatus 30 comprises an upper electromagnet 31 and a lower electromagnet 32.
25 In a manner similar to apparatus 10, upper magnet 31 is formed by a cylindrical core 33 and a coil 35 wound on the core 33 and is adapted for support on a suitable elevating mechanism, not shown. A ferromagnetic disc
30 36 having a center hole 37 is fixed to the underside of the core 33.

Lower magnet 32, which is mounted on a base, not shown, is constructed of a core 38 having a spindle 39 and a coil 40 wound thereon. A ferromagnetic disc 41 having a center
35 hole 42 is secured to the core 38 with the hole 42 engaging the spindle 39.

Ferromagnetic disc 36 is formed on its underside with a pattern of servo control signals
40 which are in the form of microscopic pits 50 marked by hatched rectangles arranged in concentric tracks 55 as shown in Fig. 4. Pit 50 on adjacent tracks differ in frequency to permit discrimination of tracks. In a typical
45 example, adjacent four tracks have different frequencies f_1 , f_2 , f_3 and f_4 and this pattern of frequencies is cyclically repeated. Likewise, the ferromagnetic disc 41 is formed on its
50 upperside with a pattern of servo control signals in the form of microscopic pits 51 arranged in concentric tracks. It will be noted that the servo control signals may also be
55 recorded in these ferromagnetic discs in the form of microscopic protuberances instead of pits. The servo control signals formed in the ferromagnetic disc 36 can thus be represented by a plurality of spaced microscopic regions of varying geometric configuration.

The uniformly magnetized floppy disc 1 is
60 placed on the ferromagnetic disc 41. Upper magnet 31 of apparatus 30 is then lowered so that the spindle 39 is received in the hole 37 and the floppy disc 1 is sandwiched between the upper and lower ferromagnetic
65 discs 36 and 41 as illustrated in Fig. 5A.

Although it is preferred that the microscopic pits 50 of upper ferromagnetic disc 36 be precisely aligned with the pits 51 of lower disc 41, a certain degree of radial displacement is allowed.

70 Upper and lower coils 35 and 40 are then energized to generate a static magnetic field in a direction opposite to the direction of flux generated in the layer 1b previously by the
75 apparatus 10. Because of the high reluctance path provided by pits 50 and 51 in discs 36 and 41, the opposite magnetic flux lines concentrate in land portions 52 and 53 unoccupied by the pits and pass exclusively through
80 the portions of the magnetic layer 1b which are in contact with the land portions 52, 53 as shown in Fig. 5B. The intensity of the opposite magnetic field concentrated in the land portions is such that it cancels the flux previously
85 generated in layer 1b and magnetizes it in the opposite direction. The pit-corresponding portions of layer 1b thus retain the previously generated flux. In this way, a magnetic pattern of servo control signals is recorded by
90 the fluxes indicated by downwardly pointed arrows in Fig. 5C. If the servo control signals are recorded in discs 36 and 41 in the form of protuberances instead of pits, magnetic fluxes indicated by the upwardly pointed
95 arrows will represent the servo control signals.

While it is preferred to use the ferromagnetic disc 41 having a servo control pattern, it is also possible to employ a ferromagnetic disc 41a having no servo control pattern. Fig.
100 6 shows a magnetic flux distribution given by an alternative form of the invention employing the disc 41a.

It will be seen from the foregoing that servo control signals can be recorded in a magnetic
105 record medium in a considerably high efficient manner with a high degree of precision not attainable with the prior art in which the record medium is scanned by a magnetic head.

If the apparatus 10 and 30 of the invention
110 are equally useful for recording servo control signals on double-sided floppy discs. Figs. 7A to 7C are illustrations of steps a double-sided floppy disc undergoes. Floppy disc 1 having magnetic layers 1b, 1c on base 1a is uniformly
115 magnetized by the apparatus 10 (Fig. 7A), and then locally magnetized in opposite direction by the apparatus 30 (Fig. 7B), resulting in a magnetic record of servo control signals on
120 each of the magnetic layers 1b and 1c (Fig. 7C).

Ferromagnetic discs 36 and 41 are formed of a material such as iron, nickel, permalloy or ferrite or any other material which is capable
125 of being eroded by etchant. Servo control pattern is produced by etching a ferromagnetic blank through a photoresist which bears a servo control pattern produced by exposure to a laser beam modulated in intensity of servo control signals and by photographic develop-
130 ment, in a manner identical to the laser cutting

method used in the manufacture of digital audio records. Specifically, the microscopic pits have a length of 10 to 30 micrometers on tracks which are spaced a center-to-center distance of about 10 micrometers. Alternatively, servo control pattern data is generated by programming a computer. Using a known photo-plotter, the servo control data is plotted on a sheet to produce a pattern of servo control signals on an enlarged scale (typically ten times larger than the size of the record medium). The servo control pattern thus produced is photographed on a reduced scale to produce an original tracking pattern on a negative, which is applied as a photomask onto a photoresist layer coated on a ferromagnetic blank to permit it to be exposed to flood light through the photomask.

The foregoing description shows only a preferred embodiment of the present invention. Various modifications are apparent to those skilled in the art without departing from the scope of the present invention which is only limited by the appended claims. Therefore, the embodiment shown and described is only illustrative, not restrictive.

CLAIMS

1. A method for recording servo control signals on a magnetic record medium, comprising the steps of:
 - a) subjecting said record medium to a first magnetic field for uniformly magnetizing the medium in a direction of the thickness thereof;
 - b) contacting the uniformly magnetized record medium in a face-to-face relationship with a surface of a ferromagnetic member on which a plurality of spaced geometrically varying regions are arranged in track turns; and
 - c) subjecting said record medium and said ferromagnetic member to a second magnetic field oriented in a direction opposite to the direction of said first magnetic field to produce a plurality of spaced regions magnetized in a direction opposite to the direction of magnetization by the first magnetic field.
2. A method as claimed in claim 1, wherein the step (b) further comprises contacting an opposite surface of said record medium with a surface of a second ferromagnetic member having thereon a plurality of spaced geometrically varying regions, the spaced regions of said first and second ferromagnetic members being identical to each other, and wherein the step (c) comprises subjecting said record medium and said first and second ferromagnetic members in said second magnetic field.
3. A method as claimed in claim 1 or 2 wherein the spaced regions of said first and second ferromagnetic members are aligned with each other.
4. A method as claimed in claim 3, wherein the spaced regions on each track turn of each of said ferromagnetic members occur at a rate different from the rate of occurrence of those

on adjacent track turns.

5. A method as claimed in claim 1, 2, 3 or 4 wherein the step (a) comprises interposing said record medium between two ferromagnetic members and magnetizing the record medium through the two ferromagnetic members.

6. An apparatus for recording servo control signals on a magnetic record medium comprising:

first magnetizing means for generating a first magnetic field in a direction of the thickness of the record medium and subjecting the record medium to said first magnetic field to uniformly magnetize the medium; and

second magnetizing means including a ferromagnetic member having a plurality of spaced geometrically varying regions arranged in track turns on one surface thereof for generating a second magnetic field in a direction opposite to the direction of said first magnetic field and subjecting said uniformly magnetized record medium and said ferromagnetic member in a face-to-face relationship with each other to said second magnetic field to produce in said record medium a plurality of spaced regions magnetized in a direction opposite to the direction of magnetization by said first magnetic field.

7. An apparatus as claimed in claim 6, wherein said second magnetizing means further includes a second ferromagnetic member contacting with a surface of said record medium opposite to the surface thereof contacting the first-mentioned ferromagnetic member, the second ferromagnetic member having a plurality of spaced geometrically varying regions identical to those of said first ferromagnetic member and means for subjecting said first and second ferromagnetic members and said record medium in said second magnetic field.

8. An apparatus as claimed in claim 7, wherein said first and second magnetizing means comprise means for aligning said spaced geometrically varying regions of each said ferromagnetic member with those of the other member.

9. An apparatus as claimed in claim 8, wherein the spaced regions on each track turn of each said ferromagnetic member occur at a rate different from the rate of occurrence of those on adjacent track turns.

10. An apparatus as claimed in claim 6, 7, 8 or 9 wherein said first magnetizing means comprises a pair of additional ferromagnetic members one on each surface of said record medium and means for subjecting said record medium and said additional ferromagnetic members in said second magnetic field.

11. Methods of recording servo control signals substantially as hereinbefore described with reference to the accompanying drawings.

12. Apparatus for recording servo control signals substantially as hereinbefore described

with reference to and as illustrated in the accompanying drawings.

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